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EDITORS' OUTLOOK

Judging from the echoes of the Washington Meeting a new era in the teaching of chemistry is here. It is clearly evident that a majority of our chemistry teachers are no longer contented to remain in their ruts, but are determined to get out on the frontier and carve out new and better ways of doing things with a confident feeling that some of their efforts will prove successful. This was most fully demonstrated when over two hundred and fifty chemical educators from the various parts of the United States gave up their time and money to come and meet with their fellow workers to talk over their common problems and take home better material and methods to use in their classes. Twenty-five formal papers were given in the Division of Chemical Education and they were discussed by a most enthusiastic audience, most of whom seemed to be looking ahead to the teaching of chemistry as a profession. This has not been true in the past. Many men and women and especially the former have gone into the teaching of chemistry with the feeling that they would teach for a while and then shift to the industries. As a rule, the drift is now in the opposite direction. This is a very hopeful sign provided the right kind of men are drifting. The facts are that the teaching of our great science is worthy of our best young men and women. A river never rises above its source nor are we likely to graduate greater chemists than we find in our teaching profession.

A new era was also demonstrated in discussing some of the fundamental questions which were taken up in committee meetings, and the business session. The details of these occasions will be given in other places, but we wish to draw your attention to the correlation of high school and college chemistry as formulated by the A.C.S. Committee on Chemical Education. This marks the first national attempt to correlate high school and college

chemistry. It promises to be a most successful issue. When this is an accomplished fact much of the uncertainty of the high school teacher will be eliminated, for the minimum requirement will be sufficiently small to save crowding our college entrance preparations. Furthermore, the teacher will have time to add local material and thereby make the chemistry more valuable and interesting to his students. On the other hand, if the colleges carry out what a majority have demonstrated their willingness to do, the student can enter practically any college, and not only get college entrance credit for their chemistry, but will be permitted to take a more advanced course than those who enter without chemistry. This will surely be a new era in this correlation problem.

The majority of those attending the meeting seemed to believe that THIS JOURNAL possesses great possibilities in ushering in a new epoch in our field of Chemical Education. Preliminary plans for the future policies of the JOURNAL were discussed, but could not be fully formulated until they were put in tune with the new constitution which is to be drawn up by the newly elected officers, and submitted at the Fall Meeting for the approval of the Council and Division.

The spirit of coöperation was the watchword of the meeting. This wonderful spirit among the teachers is the most hopeful sign of a new era.

N. E. G.

CORRELATION OF HIGH SCHOOL AND COLLEGE CHEMISTRY

At the Washington Meeting the Committee of Chemical Education of the American Chemical Society revised the "Standard Minimum High School Course in Chemistry" so that it was as near as possible in accordance with the thirty thousand criticisms which had been made available by the various state committeemen[1] and JOURNAL publications[2,3] during the past six months.

Revised Report of "A Standard Minimum High School Course in Chemistry"

The following objectives have governed the committee in its work:

1—To prepare an outline for high school chemistry which is satisfactory for students who wish to get a general knowledge of chemistry as well as for those who are going to college.

2—To list only the minimum essential topics which are common to all localities, so that the high school teacher will have time in developing the course to supplement these minimum topics with material which he considers especially suitable for his locality or for the future work of his students. See list of topics for supplementary work at end of this report.

3—To prepare an outline which would cover the essentials of any State requirements.

4—To prepare an outline which would be in tune with the syllabus of the College Entrance Examination Board.

It is the anticipation of the committee that the following objectives will govern the high school teacher in developing the outline:

1—To show the service of chemistry to the home, to health, to medicine, to agriculture, to industry, etc.—in a word, to show the service of chemistry to the country.

2—To develop this service in chemistry around these minimum standard topics, and, in doing so, to see that these minimum requirements are so well taught that they may be built upon as a foundation in college.

3—To use his own order of developing the listed topics.

4—To train the student in keen observation and exact reasoning.

5—To develop a careful correlation between recitation and experiment.

6—To encourage students to keep notebooks which shall be an accurate record of laboratory experiences expressed in concise, clear English.

7—To encourage chemistry being placed in fourth year of high school after the students have had a year of general science, and a year of biological science or physics, or preferably both.

8—To build upon the earlier science courses and knit them together in the best possible manner.

9—To encourage students to use reference books in addition to their textbook.

10—To help pupils to find themselves—*i. e.*, to discover whether they have an apti-

[1] J. CHEM. EDUCATION, **1**, 33 (1924).

[2] School Science and Mathematics, **23**, 777(1923).

[3] *Ind. and Eng. Chem.*, **15**, 1189 (1923).

tude for further study in chemistry or applied science, and, if so, to encourage such students to continue their study of science in university or technical school.

11—The teacher is urged throughout the course to stress the general principles involved in the specific cases studied.

I. Topics for a Standard Minimum High School Course in Chemistry

1—Water

(*a*) General Distribution
(*b*) Physical properties: color, odor, taste, density, boiling point, freezing point
(*c*) Solution: solvent, solute, saturated solution, process of solution, degrees of solubility, factors affecting the solubility of a substance, suspensions
(*d*) Impurities in water: what constitutes impurities; purification by boiling, distillation or filtration
(*e*) Crystallization: water vapor, water of hydration, deliquescence and efflorescence
(*f*) Chemical properties: quantitative composition of water by electrolysis and qualitatively by synthesis from copper oxide, contrasts of physical and chemical change, contrast of elements and compounds; stability of water; interaction of water with active metals; order of activity; interaction with oxides

2—Oxygen

(*a*) Preparation
Electrolysis of water
Industrial
Potassium chlorate (use of catalytic agent)
(*b*) Properties
Physical: color, odor, solubility in water, weight relative to air, weight of 22.4 liters
Chemical: tendency to form oxides in air and in oxygen, explanation of oxidation and combustion kindling temperature
(*c*) Uses: necessary to life

3—Hydrogen

(*a*) Preparation
Electrolysis of water
Industrial
Action of certain metals—*i. e.*, sodium-on water
Replacement in acids by metals
(*b*) Properties
Physical: as with oxygen
Chemical: burns in air, reduction by hydrogen
(*c*) Uses (practical): oxyhydrogen flame, balloons, hydrogenation of oils
(*d*) Hydrogen peroxide, properties and uses

4—Laws, Hypotheses, and Theories

(*a*) Law of Conservation of Mass.
(*b*) Law of Definite Composition (proportion)
(*c*) Atomic Theory including electron (simple treatment)
(*d*) Law of Boyle and Law of Charles, treated briefly with special reference to gases, not experimentally, but rather their application to the interpretation of change of volume
(*e*) Law of Gay-Lussac and Avogadro's Hypothesis

5—Symbols, Weight, Volume Relations and Chemical Changes

(*a*) Atomic weights (not their derivation), use in performing simply chemical calculations
(*b*) Molecular weights as explained by Law of Gay-Lussac and Avogadro's hypothesis
(*c*) Symbols and formulas, their meaning and use in writing equations
(*d*) Valence, with special reference to writing formulas
(*e*) Equations and their use in expressing chemical changes, including gravimetric and volumetric equations
(*f*) Problems involving (1) percentage composition (2) weights of substance and volume of gases concerned in chemical relations, and (3) the laws of gases
(*g*) Kinds of chemical changes: (1) oxidation and reduction as illustrated by direct combination, decomposition, simple replacement (substitution) (2) double replacement (metathesis)
(*h*) Energy change treated qualitatively; heat, light, electrical energy
(*i*) Formulas and writing of equations for reactions already studied

6—Air

(*a*) Percentage of oxygen and nitrogen by volume
(*b*) Tests for water vapor and for carbon dioxide
(*c*) Liquid air: principle of preparation and source of oxygen and nitrogen
(*d*) Two proofs that air is a mixture and not a compound

7—Nitrogen

(*a*) Occurrence
(*b*) Properties
  Physical
  Chemical: nonsupporter of combustion, general inactivity, negative tests
(*c*) Nitrogen fixation, as illustrated by plants, synthesis of ammonia, and oxides of nitrogen
(*d*) Uses (practical)

8—Oxides of Nitrogen

(*a*) Nitric oxide: preparation, properties, tests and uses
(*b*) Nitrogen dioxide: preparation, properties, tests and uses

9—Nitric Acid

(*a*) Preparation
  Industrial (from the air)
  Sodium nitrate with sulfuric acid
(*b*) Properties
  Chemical: action of dilute and concentrated nitric acid on copper and silver, test for nitric acid or a nitrate, decomposition products of different nitrates
(*c*) Uses: oxidizing agent, nitrocellulose industries, high explosives (briefly)

10—Ammonia

(*a*) Preparation
  Decay of nitrogenous matter
  Industrial (Haber process)
  Destructive distillation of soft coal
  Action of ammonium salt with nonvolatile base
(*b*) Properties
  Physical
  Chemical: basic character of water solution, ammonium radical, formation of ammonium salts, test
(*c*) Uses: refrigerating agent, preparation of ammonia water

11—Acids, Bases and Salts

(*a*) General properties: taste, action on litmus, etc.
(*b*) Solutions, conductors of electric current
(*c*) Activity of acids and bases

12—Theory of Ionization (briefly)

(*a*) How theory explains electrolysis
(*b*) How theory explains neutralization
(*c*) Acid and base defined in terms of ions; test for hydrogen ions and hydroxyl ions
(*d*) Atom and ion distinguished

13—Sulfur

(*a*) Occurrence
(*b*) Extraction: American method (Frasch method)
(*c*) Allotropic forms: Crystalline and amorphous
(*d*) Properties
  Chemical: direct combination with metals, for instance iron and copper
(*e*) Comparison with oxygen
(*f*) Uses: Vulcanizing rubber, making matches, making sulfur dioxide

14—Oxides of sulfur

(*a*) Sulfur dioxide
  Preparation: burning sulfur, roasting of sulfide ores, action of an acid upon a sulfite
  Properties
    Physical
    Chemical: action with water (sulfur dioxide test)
  Uses: bleaching, reducing agent, as a refrigerant

15—Sulfuric Acid

(*a*) Preparation
Contact process
(*b*) Properties
Physical: specific gravity and boiling point
Chemical: affinity for water, dilute acid on metal and concentrated acid on copper, test for sulfate ion
(*c*) Uses: preparation of other acids, with reason for the same; manufacture of fertilizers; refining of petroleum, pickling of metals

16—Hydrogen sulfide

(*a*) Preparation: ferrous sulfide and dilute hydrochloric or sulfuric acid
(*b*) Properties
Physical
Chemical: combustion, action on metals, action on solutions of metallic salts

17—Halogens

A. Chlorine
(*a*) Preparation: one industrial method (electrolysis of water solution of sodium chloride); one laboratory method (oxidation of hydrochloric acid using manganese dioxide)
(*b*) Properties
Physical
Chemical: direct combination with other elements to form chlorides, tests, comparison with oxygen
(*c*) Uses: bleaching and disinfecting action
(*d*) Compound: hydrogen chloride, (the gas) and hydrochloric acid (the solution)
Preparation: from a chloride and sulfuric acid
Properties
Physical
Chemical: a typical acid shown by taste, action on litmus and reaction with metals and bases; test for chloride ion
Use as a laboratory reagent

18—Carbon

(*a*) Occurrence
General distribution
Allotropic forms: diamond, graphite, amorphous forms
(*b*) Commercial preparation of useful forms: graphite, charcoal, lamp-black, coke, bone-black
(*c*) Properties
Physical
Chemical: affinity for oxygen, action with calcium and silicon (electric furnace)
(*d*) Uses: common fuels containing carbon or carbon compounds, operation of household stoves and furnaces, reduction by carbon, decolorizer, adsorbent

19—Carbon Dioxide

(*a*) Occurrence: relation to plant and animal life
(*b*) Preparation: burning carbon or a carbon compound, action of acid on a carbonate
(*c*) Properties
Physical
Chemical: nonsupporter of combustion, action with soluble hydroxide, brief treatment of its solubility in water, temporarily hard water, its role in nature, plant growth, and test for carbonate ion
(*d*) Uses: refrigerating, beverages, fire extinguishers, leavening agent in bread-making

20—Carbon Monoxide (Teacher's demonstration)

(*a*) Preparation: from oxalic acid, reduction of carbon dioxide by carbon
(*b*) Properties
Physical
Chemical: combustibility, reducing power
(*c*) Uses: reducing agent industrially; constituent of water gas, coal gas, and producer gas
(*d*) Illuminating and fuel gases: manufacture and uses

21—Metals in general

(*a*) Definition of metal, non-metal, mineral, ore
(*b*) Occurrence: free, combined

(*c*) General methods of extraction, roasting of non-oxide ores, reduction of oxide by carbon, electrolysis of chloride, hydroxide, or oxide
(*d*) Action of air, water (including steam) and dilute acids on the common metals
(*e*) General Methods of preparing metallic salts: neutralization, acid plus metal, acid plus salt of a more volatile acid, acid plus metal oxide, or acid plus carbonate

22—Sodium

(*a*) Preparation
Industrial: electrolysis of sodium hydroxide
(*b*) Properties
Physical: metallic luster, hardness, color, power to conduct heat and electricity
Chemical: flame test; action with water, with chlorine
(*c*) Compounds of sodium
Hydroxide: commercial preparation (electrolytic process); properties as typical base; use (cleaning agent, soap-making)
Chloride: occurrence in sea water and earth's crust; purification; use
Carbonate: preparation by Solvay process; properties; use (particularly industrial)
Acid carbonate: preparation; properties; uses; active principles of baking powders
Nitrate: occurrence; properties; uses
Flame test

23—Calcium Compounds

(*a*) Carbonate:
Occurrence; marble, limestone, shells
Properties: solubility in water containing carbonic acid (temporarily hard water), decomposition by heat, action with acids
Industrial uses: building material, making of quicklime, flux in iron furnaces, glass
(*b*) Oxide: preparation (industrial); properties; industrial uses
(*c*) Hydroxide: preparation; properties; uses (mortar, its hardening)
(*d*) Sulfate: occurrence; properties; test; uses; permanently hard water and contrast with temporarily hard water
(*e*) Bleaching powder: commercial preparation; uses, (bleaching, disinfecting)
(*f*) Calcium phosphates: Occurrence; preparation of fertilizer
(*g*) Fertilizers: presence of potassium, nitrogen, and phosphorus as ingredients

24—Iron

(*a*) Metallurgy (extraction from oxide ores—pig iron—blast furnace)
(*b*) Cast Iron: physical properties
(*c*) Uses of cast iron: castings, etc.
(*d*) Steel: manufacture (Bessemer, open hearth, and electrical processes); carbon and manganese steels with reference to their industrial uses
(*e*) Protective coatings to prevent corrosion of iron and steel: tin (tinware), zinc (galvanized iron), nickel plate, enameled ware, paint
(*f*) Compounds of iron
Sulfate: preparation; properties, uses
Chlorides (ferrous and ferric): preparation (laboratory); properties; uses; ferrous and ferric compounds; oxidation and reduction of iron compounds; change of valence

25—Aluminium

(*a*) Metallurgy (electrolytic process)
(*b*) Properties
Physical
Chemical: action with hydrochloric acid and sodium hydroxide, amphoteric
(*c*) Uses: utensils, alloys, electrical conductor
(*d*) Compounds
Hydroxide: preparation (laboratory); properties; uses, purification of water
Sulfate (alum): preparation (laboratory); properties; uses

26—Copper

(*a*) Purification by electrolysis
(*b*) Electroplating
(*c*) Properties
Physical
Chemical: action with air and acids
(*d*) Uses: electrical purposes, alloys

(*e*) Compounds of copper
Sulfate; properties; uses (water purification, fungicide)

27—Sources of Organic Compounds

(*a*) Destructive distillation of wood: methanol, acetic acid, charcoal
(*b*) Destructive distillation of coal: gas, ammonia, benzene, tar, coke
(*c*) Distillation and cracking of petroleum: gasoline, kerosene, vaseline, paraffin

28—Organic Compounds, Briefly

(*a*) Sugar
(*b*) Starch
(*c*) Acetic acid
(*d*) Ethanol (ethyl alcohol)

II. List of Topics for Supplementary Work

Not to be required for college entrance but to be introduced to add interest to the topics in the required minimum outline and to be selected according to local importance and at the discretion of the teacher. Only suggestions for the teacher.

Adhesives. Gums, paste, dextrin, glue, casein, water glass (Sodium silicate).

Artificial Stone. Lime, plaster, mortar, hydraulic cement, concrete stucco, plaster of Paris.

Beverages. Charged water, soda, mineral, infusions, tea, coffee, fruit juices (artificial flavors), fermentation.

Clay Products. Brick, pottery, stoneware, chinaware, porcelain.

Cleaning Agents. Acid: oxalic, hydrochloric. Alkalies: Sodium hydroxide, soap (emulsification). Special solvents: carbon tetrachloride, benzene. Composition of trade-marked cleaning agents.

Coal. Composition and fuel values of different varieties. Distillation of coal tar, light oil, middle oil, heavy oil, tar, pitch. Relation to dyes and explosives.

Dyeing. Direct and mordant dyes.

Explosives. Black powder, nitroglycerol, dynamite, guncotton, trinitrotoluene.

Fertilizers. Soil fertility, elements needed by growing plant and function of each. Photosynthesis and carbon dioxide cycle. Nitrogen cycle and function of nitrogen fertilizers. Use of limestone and phosphate rock.

Foods. Classification; carbohydrates, fats, proteins, mineral matter. Starch preparation from corn; cooking to dextrin and to paste; hydrolysis to glucose. Sugars: preparation and refining of beet and cane varieties; conversion to caramel; inversion. Fats: olive oil, cottonseed oil, butter, oleomargarine, hardening oils by hydrogenation. Protein: Albumins, casein, gluten, peptones, gelatin, vitamins.

Glass. Manufacture crown, flint, lead, special glasses, coloring of glass.

Ink. Iron ink, organic dye ink, carbon ink.

Leavening Agents. Baking powders (composition and reaction); yeast, soda.

Matches. Ordinary and safety types.

Metals. Used for basic purposes, iron, copper, aluminium, lead; for ornament, gold, silver, nickel; for alloys, bronze, brass, solder, type metal, antifriction or bearing metals, fusible metal; alloy steels; tests for metallic iron.

Nitrogen Fixation Manufacture by the arc, Haber and cyanamid processes. Relation to fertilizers, explosives and dyes.

Paint, Varnish, Etc. Oil paints and driers, varnish, shellac, copal, linseed oil, oil cloth, linoleum. Pigments: White lead, red lead, iron oxide, lead chromate, zinc white, lithopone.

Paper. Manufacture treated briefly.

Petroleum. Fractional distillation into burning oils, solvent oils, lubricants, paraffins. Problem of gasoline supply and possible exhaustion of petroleum.

Photography. Blueprints, plates, films, prints, toning, etc.

Poisons and Common Antidotes. Common inorganic drugs.

Preserving. Sterilizing, pasteurizing, desiccating, pickling by salt and sugar; common chemical preservatives and tests for them.

Refuse Disposal. Sewerage, garbage; fermentation and putrefaction; civic problems; disinfectants and deodorizing agents.

Silicates. Treated briefly.

Textile Fibers. Natural and artificial silk. Wool: scouring, bleaching, felting, etc. Cotton: bleaching, mercerizing, etc

Wood. Distillation of wood to produce methanol, acetone, acetic acid, charcoal.

III. Additional Topics

Not to be required for college entrance but to be added if time permits.

Alloys, other than those containing copper
Arsenic Insecticide
Bromine and iodine, treated similar to chloride
Catalysis
Colloids, common examples and their application
Electromotive series
Electronic structure of matter, simple interpretation
Gold
Hydrogen equivalent (reacting weights not atomic weights)
Hydrogen sulfide with special reference to treating for certain metals
Iron Compounds: Oxides, hydroxides, and sulfates
Lead: properties, uses and compounds
Magnesium: properties, uses and compounds
Mercury: properties and uses of the metal and of the chlorides
Periodic Table
- **(*a*) Elements arranged in order of atomic weights**
- **(*b*) Relation of valence to group numbers**
- **(*c*) Gradual transition from metals to nonmetals in passing from Group I to Group VII**
- **(*d*) Variation of metallic nature with variation of atomic weight within the group**
- **(*e*) Single elements as types of groups**
- **(*f*) Statement of Periodic Law.**

Phosphorus: preparation, properties and uses
Radium and Radio Activities
Rare gases of the air
Silver: properties and uses; relation to photography
Zinc: metallurgy, properties, uses and salts

Since the problem is the correlation of high school and college chemistry it was felt by the committee that this high school outline could not be perfected until a preliminary minimum First Year College Outline had been formulated, and published along with the revised High School Outline. This has been done, and chemistry teachers are earnestly requested to give both outlines their most careful consideration while constantly making comparisons between the two. Our aim should be to make the overlapping a minimum. Where overlapping is necessary it should be worked out in sufficient detail so that each teacher will know his responsibility.

Preliminary Report of "A Minimum First Year College Course in Chemistry"

It has been necessary to make only a few changes in the objectives as given in connection with the high school outline to make them applicable to the college outline.

1—To prepare an outline for college chemistry which is satisfactory for students who wish to get a general knowledge of chemistry as well as for those who are to continue their work in chemistry.

2—To list only the minimum essential topics which are common to all localities, so that the teacher will have time in developing the course to supplement these minimum topics with material which he considers especially suitable for his locality or for the future work of his students.

3—To prepare an outline which would not be a repetition of the "Standard Minimum High School Course in Chemistry."

It is the anticipation of the committee that the following objectives will govern the college teacher in developing the outline:

1—To show the service of chemistry to the home, to health, to medicine, to agriculture, to industry, etc.—in a word, to show the service of chemistry to the country.

2—To develop this service in chemistry around these minimum standard topics, and, in doing so, to see that these minimum requirements are so well taught that they may be built upon as a foundation in any science.

3—To use his own order of developing the listed topics.

4—To train the student in keen observation and exact reasoning.

5—To develop a careful correlation between recitation and experiment.

6—To encourage students to keep notebooks which shall be an accurate record of laboratory experiences expressed in concise, clear English.

7—To build upon the earlier science courses and knit them together in the best possible manner.

8—To encourage students to use reference books in addition to their text-book.

9—The teacher is urged throughout the course to stress the general principles involved in the specific cases studied.

Topics for the Preliminary First Year College Course in Chemistry

Since this is the first publication of the college outline it is expected that drastic changes will be necessary before its final adoption.

Structure of Matter

1—Fundamental Laws (experimentally derived)

(*a*) Law of conservation of mass
(*b*) Law of definite proportion (composition)
(*c*) Law of multiple proportion
(*d*) Law of equivalent weights (Hydrogen equivalent)

2—Atoms, Molecules and Electrons

(*a*) Dalton's hypothesis
(*b*) Definition of atom and molecule
(*c*) How Dalton's hypothesis explains laws of definite and multiple proportion
(*d*) The structure of the atom (electrons)

3—Properties of Gases (experimentally)

(*a*) Contrast general properties of solids, liquids, and gases
(*b*) Relation of temperature to volume under constant pressure (Charles' Law)
(*c*) Relation of pressure to volume under constant temperature (Boyle's Law)
(*d*) Problems involving a simultaneous application of the two laws including correction for water vapor and difference in level
(*e*) Law of Gas Volumes (Gay Lussac's Law)
(*f*) Avogadro's hypothesis

4—Molecular and Atomic Weights (experimentally)

(*a*) The Determination of the weight of one liter of oxygen
(*b*) Determination of molecular weight of hydrogen taking oxygen as a standard
(*c*) Determination of molecular weight of substances which cannot be vaporized without decomposition
(*d*) Determination of atomic weights

5—Symbols, Formulas, Calculations

(*a*) Full meaning of symbol and formula
(*b*) Calculation of formula
(*c*) Percentage composition calculated from the formula
(*d*) Naming of chemical compounds

6—Valence

(*a*) Electronic conception of valence
(*b*) Given the formula to find the valence
(*c*) Given the valence to write the formula

7—Chemical Equations and Calculations

(*a*) Steps in writing an equation
(*b*) Review different types of equations
(*c*) Review oxygen, hydrogen and water by writing equations involving them, classifying such equations according to (*b*)
(*d*) Equations as a basis of chemical reactions:
Where weight alone is involved
Where volume alone is involved
Where both weight and volume are involved

The Periodic System

1—History

(*a*) Newland
(*b*) Mendeleeff and Meyer
(*c*) The periodic table according to Mendeleeff

2—Discussion of Tables as to

(*a*) Valence changes
(*b*) Property changes
(*c*) Place of hydrogen
(*d*) The rare gases
(*e*) Two families in a group
(*f*) Radium elements

3—Advantages of Table

(*a*) Aid in classification
(*b*) Prediction of new elements
(*c*) Correcting atomic weights
(*d*) Stimulating research

4—Harkin's Table

(*a*) Discussion of the table

5—Atomic Numbers

(*a*) Significance of atomic numbers
(*b*) Periodic table including atomic numbers

Phosphorus Group

1—Introduction

(*a*) Position in periodic table
(*b*) Contrast of their constants by table
(*c*) Contrast of their significant compounds
(*c*) Reference to nitrogen already studied

2—Phosphorus

(*a*) Occurrence
(*b*) Preparation
Industrial
(*c*) Properties
Physical
Chemical
(*d*) Allotropic forms
White
Red
(*e*) Uses
Poisonous ingredients
(*f*) Compounds
Chlorides: preparation, properties and uses

Oxides: preparation, properties, uses
Acids
Orthophosphoric: preparation, properties, test
Metaphosphoric: preparation, properties, test
Phosphides
Hydrogen phosphide (phosphine): preparation and properties
Calcium phosphide
Sulphur phosphide

(*g*) Use of phosphorus in Fertilizers

3—Arsenic

(*a*) Occurrence
(*b*) Preparation
(*c*) Properties
(*d*) Compounds: oxides, halides, arsine, acids, sulfides, and sulfo acids
(*e*) Uses

4—Antimony

(*a*) Occurrence
(*b*) Preparation
(*c*) Properties
(*d*) Uses
(*e*) Compounds: oxides, acids, and salts

5—Bismuth

(*a*) Occurrence
(*b*) Preparation
(*c*) Properties
(*d*) Compounds: oxide, subchloride, subnitrate, and subcarbonate
(*e*) Alloys

Ionogens

1—Acids, Bases, and Salts

(*a*) General properties (Review)
(*b*) Normal, and molar solutions

2—Arrhenius' Theory of Ionization

(*a*) Indications that acid bases and salts ionize in aqueous solution: conductivity, osmotic pressure, and boiling and freezing point
(*b*) How Arrhenius' Theory explains: electrolysis, conductivity and freezing and boiling point

3—Action and Interaction of Ionogens

(*a*) Electronic conception of ionization
(*b*) Factors affecting degree of ionization
(*c*) Activity of acids and bases
(*d*) Full significance of neutralization

4—Chemical Equilibrium

(*a*) Factors affecting the speed of reaction
(*b*) Reversible reactions (Kinetic explanation)
(*c*) Conditions under which reactions go to completion
(*d*) Factors affecting equilibrium: temperature, pressure, concentration, catalyst, common ion effect
(*e*) Equilibrium relations in water
Hydrolysis
Hydrolysis of different types of salts

Sulphur Group

1—Introduction

(*a*) Reference to the study of sulphur as taken up in high school
(*b*) Manufacture of sulfuric acid (lead chamber process)
(*c*) Table showing similarity of sulphur to selenium and tellurium

2—Selenium

(*a*) Preparation
(*b*) Properties and uses

3—Tellurium

(*a*) Preparation
(*b*) Properties and uses

Halogen Group

1—Introduction

(*a*) History
(*b*) Position in periodic system
(*c*) Comparison of their constants

2—Preparations as Compared with Chlorine

(*a*) Bromine
(*b*) Iodine
(*c*) Fluorine

3—Properties

(*a*) Study the properties of bromine, iodine and fluorine as compared to chlorine
(*b*) Tests, as compared to chlorine

4—Uses of the Halogens

5—Compounds of Halogens (Bromine Iodine, and Fluorine as Compared with Chlorine)

(*a*) Hydrides: preparation, properties and uses
(*b*) Salts: methods of formation and tests
(*c*) Oxides of chlorine
(*d*) Oxygen acids: hypochlorous acid and its salts, bleaching powder and its use, chloric acid, perchloric acid, hypobromous acid, hypoiodous acid, bromic acid, iodic acids, and periodic acid
(*e*) Relative stability of oxygen acids

Electronic Changes

1—Oxidation and Reduction

(*a*) Review of some instances of oxidation and reduction
(*b*) Electronic conception of oxidation and reduction
(*c*) Oxidation and reduction as applied to two elements: examples of oxidation as applied to two elements
(*d*) Oxidation and reduction as applied to an element and a compound: balancing of electrons in a compound; examples which apply to elements and compounds
(*e*) Oxidation and reduction as applied to two compounds: examples; intensity of activity of oxidizing and reducing agents

2—Electrochemistry

(*a*) Ionic displacement and electronic conception of same
(*b*) Electrolytic cell
(*c*) Solution pressure
(*d*) Electronic conception at the electrodes
(*e*) Oxidation and reduction at electrodes from an electronic standpoint

Carbon Group

1—Introduction

(*a*) Review of work on carbon
(*b*) Table showing relation of carbon to silicon
(*c*) Reason for so many organic compounds
(*d*) Homologous series
(*e*) Electronic conception of valence as applied to organic compounds

2—Hydrocarbons: methane, ethylene, acetylene, petroleum, benzene, toluene

3—Derivatives of Hydrocarbons

(*a*) Alcohols: methyl, ethyl, and glycerine
(*b*) Aldehydes: formaldehyde and acetaldehyde
(*c*) Acetone
(*d*) Acids: formic and acetic acid
(*e*) Esters: fats; soaps
(*f*) Carbohydrates: sugars; cellulose
(*g*) Foods: vitamines; digestion; food values

4—Silicon

(*a*) Introduction (similarity to carbon in respect to compounds)
(*b*) Preparation
(*c*) Properties
(*d*) Compounds: silica; silicic acid, silicon tetrachloride, water glass and silicates

Colloid Chemistry

1—Introduction

(*a*) What is meant by colloidal chemistry
(*b*) Size of colloidal particles
(*c*) What field is covered by colloidal chemistry?

2—Reasons for Colloidal Particles not Settling Out

(*a*) Electrical charges
(*b*) Movement (Brownian)
(*c*) Protective film

3—Preparation

(*a*) Condensation method
  Formation by chemical replacement at low concentration of ions
  Reduction
  Hydrolysis
(*b*) Dispersion methods
  Grinding
  Electric arc methods
  Emulsification
  Peptization

4—Properties

(*a*) Dialysis
(*b*) Ultrafiltration
(*c*) Conductivity

5—Adsorption

(*a*) Charcoal
(*b*) Gels

6—Application of Colloids

Metals

1—Introduction

(*a*) General properties of metals
(*b*) General occurrence
(*c*) Displacement Series
(*d*) General processes of Metallurgy

2—Alkali Group (Na, K, Li, Include NH_4)

(*a*) Occurrence
(*b*) Properties and uses
(*c*) Compounds: Na(OH), NaCl, Na_2SO_4, Na_2CO_3, NaH CO_3, $Na_2B_4O_7 10H_2O$
(*d*) Qualitative analysis of group

3—Magnesium (Mg)

(*a*) Occurrence
(*b*) Preparation: properties and uses
(*c*) Compounds: $MgCO_3$, MgO, $MgSO_4$, $Mg(OH)_2$
(*d*) Study of test and analytic reactions of magnesium

4—Alkali Earth Group (Ca, Sr, Ba)

(*a*) Occurrence
(*b*) Preparation
(*c*) Properties and uses
(*d*) Compounds
  Calcium: $CaCO_3$, CaO, $Ca(OH)_2$, $Ca(H_2PO_4)_2$
  Strontium: $Sr(OH)_2$, $Sr(NO_3)_2$, $SrBr_2$
  Barium: $BaCl_2$, $Ba(OH)_2$, BaO, BaO_2, $Ba(NO_3)_2$
(*e*) Qualitative analysis of the group

5—The Ammonium Sulphide Group (Al, Fe, Cr, Mn, Zn, Ni, Co)

(*a*) Occurrence
(*b*) Preparation
(*c*) Properties and uses
(*d*) Compounds
Aluminum: $Al(OH)_3$, Al_2O_3, $Al_2(SO_4)_3$, $Al(CH_3COO)_3$
Iron: $FeCl_3$, $FeCl_2$, Fe_2O_3, Fe_3O_4, $Fe(OH)_3$, FeS
Chromium: Cr_2O_3, CrO_3, K_2CrO_4, $K_2Cr_2O_7$
Manganese: MnO_2, Mn_2O_7, Mn_2O_3, K_2MnO_4, $KMnO_4$
Zinc: $ZnCO_3$, $ZnSO_4$, ZnO, $ZnCl_2$
Nickel: $NiSO_4$, $Ni(OH)_2$, NiS
Cobalt: $CoCl_2.6H_2O$, $Co(OH)_2$, $CoSO_4.7H_2O$, CoS
(*e*) Qualitative analysis of the group

6—Hydrogen Sulphide Group (Hg, Pb, Bi, Cu, Cd, As, Sb, Sn)

(*a*) Occurrence
(*b*) Preparation
(*c*) Properties and uses
(*d*) Compounds:
Mercury: HgS, $Hg(NO_3)$, $Hg(NO_3)_2$, $HgSO_4$,HgCl, $HgCl_2$
Lead: PbO, PbO_2, Pb_3O_4, $Pb(NO_3)_2$, $Pb(CH_3COO)_2$, $PbCO_3$, $PbCrO_4$, $PbSO_4$, $PbCl_2$, PbS
Bismuth: $BiONO_3.H_2O$, BiOCl, $(BiO)_2CO_3.H_2O$
Copper: CuO, $Cu(OH)_2$, $CuSO_4$, $KCu(CN)_2$, CuS
Cadmium: CdO, $Cd(OH)_2$, CdS
Arsenic: previously studied (review)
Antimony: previously studied (review)
Tin: $SnCl_2$, $SnCl_4$, SnO, SnO_2, H_2SnO_2
(*e*) Qualitative analysis of group

7—Hydrochloric Acid Group (Ag, Hg, Pb)

(*a*) Occurrence
(*b*) Preparation
(*c*) Properties and uses
(*d*) Compound
Silver: $AgNO_3$, AgCl, AgI, Ag_2O, $Ag(NH_3)_2Cl$
Mercury: previously studied
Lead: previously studied
(*e*) Qualitative analysis of group

8—Outline of Qualitative Analytical Procedure when Groups are all together

9—Qualitative Analysis of Acid Radicals

Every chemist should help in this most important problem. It is a humiliation to think chemistry is so far behind English and Mathematics in this correlation work. If we all do our best it can be a workable plan within one year. It will never be perfect or complete. Chemistry with its new discoveries will constantly cause changes in both the high school and college curriculum. Our National Journals, Division of Chemical Education, and increasing number of State Associations of Chemistry Teachers should enable any such changes to be easily and quickly introduced.

Send any criticisms to the Chairman of the Committee on Chemical Education of the American Chemical Society, University of Maryland, College Park, Maryland.

NEIL E. GORDON, *Chairman*
B. S. HOPKINS
J. R. KUEBLER
L. W. MATTERN
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R. E. ROSE
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R. E. SWAIN
T. G. THOMPSON
F. W. WILLARD

LABORATORY EXERCISE IN ATOMIC STRUCTURE*

WILLIAM LLOYD EVANS AND JESSE E. DAY, OHIO STATE UNIVERSITY, COLUMBUS, OHIO

This paper deals with an account of some experiments carried on by a class of six hundred students in making atomic models of the Lewis-Langmuir type. These students were those who had entered the University with High School Chemistry as an entrance unit. It seemed to us that this fruitful theory would have much more meaning if the students themselves could be actually given the task of building their own models rather than merely making drawings of them. In this connection we were anxious to show that the octet theory of the atom seemed to harmonize with (1) the Periodic Law, (2) the facts of chemical combination (valence), and (3) with the theory of electrolytic dissociation. We also used the excerise to illustrate the meaning of the terms, isosteric elements and isosteric compounds.

Each laboratory section was divided into small groups of three or four students. To each group was assigned a different problem. To illustrate our procedure, we will take the group which had to construct the atomic model for oxygen. From the periodic arrangement they found the atomic number for oxygen to be eight. They then deducted the two electrons of the first shell, after which they quickly saw that there would be six valence electrons in the second shell. The group working on the potassium atom deducted the two first shell electrons from the atomic number, 19, and then saw that they would have two complete layers ($2 \times 8 = 16$) of electrons in the second shell, the remaining electron being the valence electron, located in this case in the third shell. (Fig. 1)

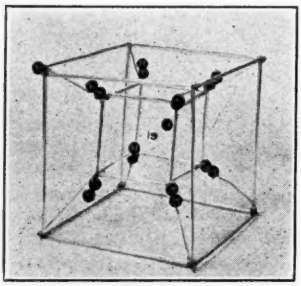

Fig. 1.—Atomic model of the potassium atom.

Each group was assigned one of the elements in either Series 1 or 2 or argon and potassium of Series 3 of the periodic arrangement of the elements. After the completion of the construction of these models, the laboratory section was assembled and the elements in the order of their atomic numbers were presented for discussion and study. In quite a few instances the electrons were not symmetrically arranged, which afforded opportunity for constructive criticism on the part of the students. Thus the class as a whole was able to see at a glance how beautifully the octet theory harmonized with the Periodic Law. Another effective way of showing the same thing was accomplished without our suggestion, by the group which

* Read in the Division of Chemical Education of the American Chemical Society, at the Washington Meeting, April 24, 1924.

prepared the helium model. (Fig. 2) This group carried through Series 1 by the addition of electrons to the helium model, each time remembering that the charge on the nucleus was changing. In many cases the models were constructed in such a way that electrons could be added to or removed from the models, depending on the nature of the problem assigned to any group.

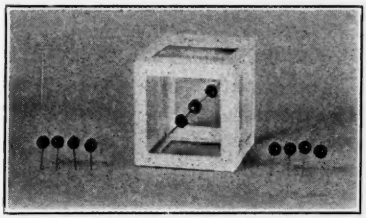

Fig. 2.—Atomic model of the helium atom and bead electrons.

The facts of chemical combination were illustrated either by the assignment of definite chemical compounds for model building, or by having the student groups combine atomic models previously constructed. The construction of molecular models was carried out by first having the students calculate from the fundamental equation of Langmuir ($e = 8n - 2p$) the number of co-valences in the compounds chosen before proceeding with their task. This they saw was the first essential. Carbon dioxide and nitrous oxide are shown in Figs. 3 and 4, respectively Carbon tetrafluoride lends itself as an interesting structure to show combination at the edges of the cube.

After the atomic models of several of the elements had been made, it was an easy matter for the students to see how it would be possible for one atom to lose electrons to another, such as in the case of lithium fluoride (Fig. 5) in which the fluorine atom has gained an electron from the lithium atom. Hence lithium has one less electron than its atomic number and

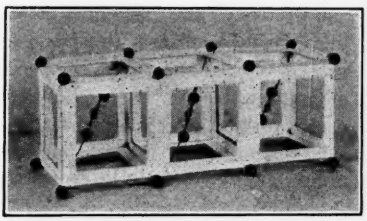

Fig. 3.—Molecular model of carbon dioxide (cardboard construction).

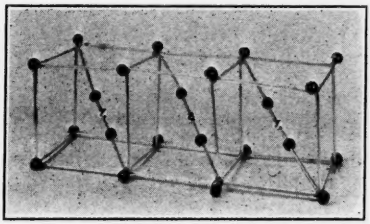

Fig. 4.—Molecular model of nitrous oxide (wire and glass construction).

fluorine one more electron than its atomic number. Attention was frequently directed to the fundamental difference between the atom of an element and its ion.

We used carbon dioxide and nitrous oxide (Figs. 3 and 4) as illustrations of isosterism in compounds. The striking similarity in many of the

physical properties and the well known chemical behavior of these two compounds proved of much interest to the students. Furthermore, attention was directed to cases of isosterism among certain elements, such as the lithium ion and the helium atom.

Experimental Part

The students were asked to furnish their own special equipment such as a foot rule, scissors, pliers and a Sloyd or other substantial knife.

Materials.—Two types of cubes were used in the construction of these models: (1) The one type was made of glass-tubing (inside diam. = 2 mm.) strung on No. 18 bare copper wire; (2) the other type was of white 10-ply cardboard with the edges fastened together by means of white passe-partout binding (or gummed cloth). An axially drilled red wooden bead (diam. = 1.3 cm.) was used to represent an electron and a white (or black) bead (diam. = 1.3 cm.) with the proper atomic number printed thereon as the positive nucleus. Although the Lewis-Langmuir atom has the symmetrically arranged parts of the helium nucleus on an axis parallel to any edge of the cube, we found it mechanically less troublesome to suspend these nucleus beads in a diagonal position.

Procedure.—1. *Wire Type.* (*a*) To construct an atom having but one shell (See the lithium ion cube, Fig. 5). Cut and fire-polish twelve lengths (10 cm. each) of glass tubing. Thread a $2^1/_2$ meter length of the copper wire through the twelve pieces of glass tubing so as to give a cube. Pass a $26^1/_2$ cm. length of copper wire through a red, a white and a red bead and diagonally attach the wire between any two opposite corners of the cube. The beads can be held in place on the wire by the use of proper lengths of glass tubing or small wooden wedges made from match sticks.

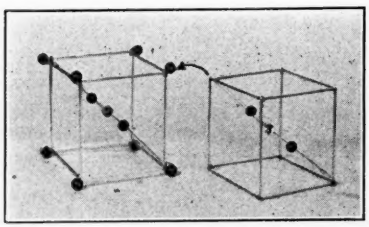

Fig. 5.—Lithium ion and fluorine ion (wire and glass construction).

(*b*) To make an atom having two shells with one to eight electrons in the first layer of the second shell. Attach, leaving a free end, at the appropriate corners of the helium cube (See (*a*)), as many 5 cm. lengths of wire as are required for the atom in question. Place a red bead on each of these wires and bend the end of the wire over the bead, thereby, securing the bead in position. This layer of electrons can be placed immediately inside of the cube or immediately on the outside of it.

(*c*) For an atom having one to eight electrons in the second shell. Add the second layer to the cube constructed in (*b*). Several arrangements are possible in this model: (1) The corner wire can be made sufficiently long so

as to accommodate two layers of the beads on the outside of the cube (See the inner cube of the potassium atom, Fig. 1) or the two layers can be placed immediately within the cube; (2) the wire can be attached so as to leave one free end on the inside and the other on the outside of the cube; (3) a second cube can be built around and close to the first cube with its electrons. Additional modifications are suggested by these arrangements.

2. *Cardboard Type.*—To build a helium atom. (See Fig. 2.) Cut out a piece of cardboard conforming to either of the two designs shown in Fig. 6, fold on the dotted lines and bind the edges together with either the

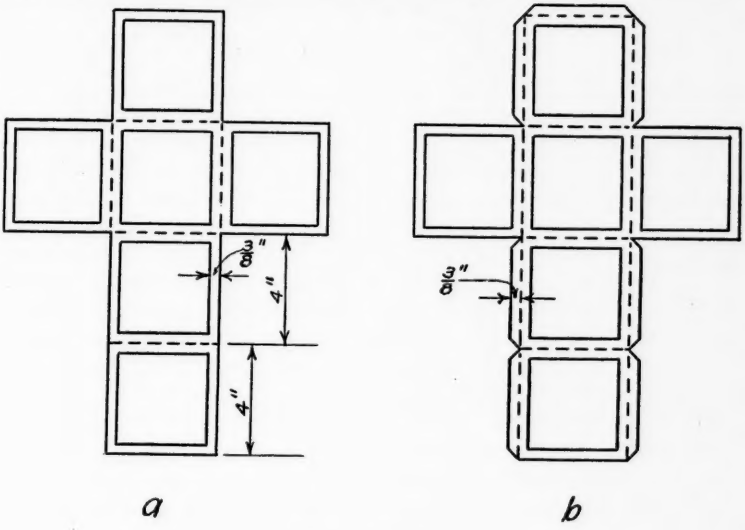

Fig. 6

Fig. 6.—Cardboard design.

gummed paper or the gummed cloth. A neater fold can be accomplished if a sharp knife blade is first lightly drawn over the dotted lines. Thread a copper wire through the helium nucleus beads as in the glass tubing type of model. Pass the ends of the wire through any two diagonally located corners of the cube and spirally tie the wire on the outside of the cube; or spirals can be made on each end of the wire so that when properly placed in the cube the wire will be held in position due to the pressure exerted by these spiral ends. The first layer of red beads (electrons) in the second shell can be attached to the corners of the cube by means of wire brads of the proper length and gauge. A second layer of red beads can be strung on the same brad and both layers are most conveniently placed on the outside of the cube.

The cardboard model does not easily lend itself to the construction of atoms having more than two shells. However, it is neater than the wire-glass tubing type but is not as accessible to the vision as the latter type. The difference in the two types is well shown in the models for carbon dioxide (Fig. 3) and nitrous oxide (Fig. 4).

Discussion

Dr. Sy, University of Buffalo.—I would like to state that if at Ohio State, they have 600 freshmen who will do this kind of work, this man is to be congratulated. I am very sure that we cannot interest freshmen to the extent of making models like that.

Father Ahern, Holy Cross College, Worcester, Mass.—There is a very simple oil drop apparatus made by a company in Chicago who is willing to make this apparatus if they can get ten orders for the small price of $50.00. (Central Scientific Company). A movement has been started by the Northeastern Section of the American Chemical Society for getting a film illustrating the structure of the atom. It has been estimated that one can be made for about $15,000 by Edwin Mills Fadman, Inc., 1600 Broadway, New York City, producers of the Einstein Films. Such a film illustrating the structure of the atom would treat the subject historically with animated cartoons and be edited and revised by such men as Langmuir, Millikan, Lewis and others. For a while it could be rented at about $3.00 per day for four reels to college and high school teachers until its initial cost had been met. After which time it will become the property of the American Chemical Society for possible free use.

Dr. Coates, University of Louisiana.—These are very good suggestions and they would be more effective if the names, addresses and prices could be taken care of by our Secretary, but I take all these down and then lose them.

Dr. Evans.—We have just tried this once. The electrons are merely red beads purchased from Mr. Woolworth for 10 cents. Materials are especially cheap.

MAKING HIGH SCHOOL CHEMISTRY WORTH WHILE

C. E. OSBORNE, HEAD OF CHEMISTRY DEPARTMENT, OAK PARK-RIVER FOREST TOWNSHIP HIGH SCHOOL, OAK PARK, ILLINOIS

I count it a privilege to have devoted my life to the teaching of chemistry to high school boys and girls. Any achievement, mental or material, involves certain factors. Whether it is to prepare and determine the properties of oxygen, to build a radio set, to build a sky-scraper, or to teach chemistry, these factors are strikingly similar.

To release the angel from the stone demands a sculptor, a vision, hammer

and chisel with which to work, the stone to be hewn, and the statue is the vision become reality. I am not teaching angels or making angels, but the analogy is not so far fetched when one remembers that each boy and girl has within him or her the possibility of immortality.

To make high school chemistry worth while demands a teacher who must know definitely what he is trying to do. He must have equipment with which to work, he must understand the boy or girl to be fashioned, and he must have a definite plan of work. His final product is the answer to the question, "What manner of man or woman shall this child be?" No one could adequately discuss this subject in the fifteen minutes allotted to me. Some mercenary fellow, for the sum of ten dollars, agreed to tell anyone how to learn the German language in six days. In reply to the "ad" a student received the following; "Divide the German language into six equal parts and learn one part each day." Somewhat similarly, I am compelled to ask the indulgence of your patience for three minutes or less on each of the previously mentioned factors.

The Teacher

The most important factor concerned here is the teacher—a real, not an artificial teacher. I am still inclined to believe that they are born and not made. He must know his subject, I do not object to the Master's degree. Other things being equal, it is an asset, but sufficient number of years of experience and good sense must prevent him trying to make masters in one year of high school boys and girls. *It can't be done.* He must be interested in young people, must know their problems and experiences, and he should know the applications of chemistry so familiarly that he lives his chemistry, thinks his chemistry, and can speak the language. He must be a man first and a teacher after, for "what you are, influences me more than what you say you are."

The chemistry teacher who helped me most knew the least about chemistry, but he took a personal interest in me. But for that man, I believe I should not be here today. A seemingly small incident completely changed my attitude toward, and interest in life. I became interested in the experiment illustrating spontaneous combustion by adding two or three drops of concentrated sulphuric acid to a mixture of potassium chlorate and cane sugar. I had sugar at home of course, but no potassium chlorate or sulphuric acid. Dubiously, I asked the instructor whether he would sell me a small amount of each of these (money was scarce those days and I was not accustomed to have anyone give me anything for nothing). I was filled with gratitude when he said, "Mr. Osborne, the whole outfit belongs to you, just help yourself." In all my years as a teacher I have gladly, within reasonable limits, given chemicals and glassware to pupils when I have been assured of their sincerity. This probably

is largely responsible for the fact that although I have no locks or doors on my chemical cases or storeroom, I can honestly say that in the past twenty years I have no reason to believe that five dollars worth of materials have been stolen from my supplies.

Sensing my interest in experiments, the instructor asked another boy and myself if we would like to stay after school to try the experiments for the next lesson and make them before the class the next day. We had that job permanently after that first day. Little acts of tact and judgment like these are worth far more than a knowledge of Charles' Law to the boy or girl on the threshold of life.

So many teachers who visit me ask what text and manual I use, and beam with satisfaction when they can say that they use the same as I, as though that were positive proof that their work is as good as mine. It may be. It may be better; but the text and manual are only tools. It is an advantage to have good tools with which to work, and a great variety of tools in your kit, but it makes all the difference as to who uses the tools.

One man with saw and hammer can make only a crude box but another, with the same, will make a beautiful cabinet. The artist is the soul of the violin. There may be music in a common-place song, but it needs the personality of a Galli-Curci or a Caruso to reveal its true beauty.

The Purpose, or What I Am Trying to Do

There are some things that I am not trying to do. I am not trying to make chemists, although I believe I have helped to make my share. I am not teaching chemistry so much for the sake of the chemistry, but as a means for developing boys and girls. Few will become chemists. As many will use chemistry later in one way or another and will continue this work in the university, I will work with that thought in mind, but I believe that through a knowledge of chemistry, all pupils "may have life, and have it more abundantly."

I am making no special effort to meet college entrance requirements. I feel that they are so reasonable that I see to it that they get what they ask for, good measure, pressed down and running over. I am an ardent advocate of the doctrine of the spare tire. There is wisdom in what the young man said when I asked him how he was getting on at college. He said, "Better than the first semester, and with less effort." I said, "How so?" He said, "I have learned to find out what the teacher wants and then see that he gets it."

I am not trying to complete the text. I cannot. I met a teacher the other day who said he had to go through the book twice in order to fill out the year. Quality is preferable to quantity.

I use my own judgment in omitting anything from the text and selecting

the subject matter. The best efforts of a chemistry teacher are necessary for the presentation of chemical theory and nomenclature. The discussions of these topics in many texts are impossible. I believe that most of the failures in chemistry can be traced back to these subjects. I cannot include qualitative analysis for there is not time to do this properly in a one year course.

To avoid repetition, I will state definitely what I am trying to do at the close of this paper.

The Equipment

The teacher should be a college or university graduate, approaching his best after an experience of ten years. It would make little difference which one of eight or ten modern texts he used. A laboratory manual written by the author of the text is most desirable. While one can use his own discretion in omissions and corrections, the order of sequence of laboratory experiments should preferably be the same as the topics discussed in the text.

For years Mark Hopkins and his log have enjoyed an enviable reputation, but in these days of splendidly equipped science laboratories, even Mark Hopkins would need something more than a log to maintain his prestige if he attempted to teach chemistry. A well equipped laboratory, where pupils have every convenience and work individually, is most desirable. When the state supervisor of high schools asked me to tell him the minimum of equipment to teach chemistry that I considered necessary to make it worth while, in a small high school, I said, "a bucket of water for water supply, an empty water bucket for a waste jar, a kitchen table, a spirit lamp, and a ten dollar supply of chemicals." No, I am not thinking of a Chemkraft outfit nor any of its offspring. I have no more use for them than I have for the chemical engineer's diploma that goes with them. I am an enthusiast and an optimist on the teaching of chemistry, but not that kind.

There must be a note-book. I have no patience with short cuts for writing up experiments. I adhere to the logical outline, but try to "keep my eye on the ball" and make sure the pupil gets the point of the experiment. While I insist that writing must be in ink and note-books neat, with a correct cross-sectional drawing with pencil, I do not wear the pupil out with re-writing and re-copying. We use a stencil for drawing and while I hesitated at first, the advantages so overbalance the objections, that I would not think of giving them up. If it may be classed as equipment, I should like to have a sympathetic principal and community, and if I have not, my first duty is to convert them.

The Boy

A statement recently published by the Metropolitan Life Insurance Company of New York asserts that between the ages of twenty and thirty,

is the egotistical period when the boy thinks he knows more than his father. From thirty to thirty-five, the boy is changing his mind and considers his father a man of fair judgment. From thirty five to forty, the son realizes that life is a reality, that he is not so smart as he thought, and that his father was really a man of master mind. They do not attempt to say what the boy is between fifteen and twenty years of age. You and I know that he is like plastic clay,—impressionable, often developing so fast physically that his mentality is below normal, slow to respond to the help we offer him and we become impatient. But the developing of character is an unfolding involving the element of time. We say he does not think when we mean that he does not think as we do, or to the degree we desire. Experience and observation has convinced me that every child thinks some. It would be sacrilege to suggest that probably the reason the child does not think satisfactorily is to be found in the teacher.

Care-free, bubbling over with energy—the surest sign of life and health,—acting on the impulse of the moment when maturity would have taught one to think and then act or not act at all,—unable to appreciate the daily task because he cannot see of what direct use it may be to him,—a ship without a compass. It is your privilege and mine to help to turn his face in the right direction.

The Plan

To understand my problem I must learn at the beginning, the age of the pupil, his class rank, whether he has studied physics, what college or university he expects to attend, if any, and why he is studying chemistry.

I must first create an interest and will therefore try to show the practical application of each day's work. I also require each pupil to read Slosson's Creative Chemistry by the end of the first semester. I cannot be satisfied to have the interest of the pupil only, but desire the support of the entire community as well. This can be secured by directing the attention of the public to the application of chemistry to everyday life, to the local industries, and to the chemistry of the time. Public lectures, articles in the local papers, and the annual open house or chemistry exhibits are valuable. This chemistry exhibit or open house has been described in detail in School Science and Mathematics, February, 1921. Whereas not more than 10 visit the regular work during the year, from 500 to 1000 visit the exhibit. In addition to being interesting and practical, the work must be made up-to-date, and must require an effort on the part of the pupil.

Formal lectures have little place in a high school class-room. The recitation combining the knowledge from the laboratory and the text, and emphasizing the application of the work at hand is most valuable. Each day's lesson is more or less of a review and constant reviewing is necessary to make these new facts permanent.

The Final Product, or What Can Be Accomplished

What can a real teacher, with all the necessary equipment, and free to use his own best judgment, do for the average high school junior or senior?

1. He can give him a foundation broad and deep enough to permit the erection of any chemical edifice that may later be attempted.
2. He can present the subject in an attractive way so that the pupil can determine whether his interests lie in this direction.
3. He can add another tool to his kit.
4. He can improve his power of observation.
5. He can help him to think straight because he sees correctly. Good judgment is the result of sound thinking, and sound thinking is the result of accurate observation.
6. He can give him a respectful attitude toward chemistry and the work of the chemist.
7. He can give him more confidence in himself and in his ability to do things.
8. He can train the hand as well as the mind and train it to coöperate with the mind. Try to run an auto without this coördination.
9. He can enlarge his vision both positively and negatively,—to larger worlds than this and also smaller,—from the test tube experiment of the laboratory to its application in industry, and from the smaller tasks of the class-room to the larger tasks in life.
10. He can unconsciously help him to be honest, open minded, and fair in judgment.
11. He can help him to give a truthful, intelligent report on any piece of work that he has done.
12. He can help him to attack and solve life's problems in a logical, scientific way,—the best way.
13. He can create in him a more reverent attitude toward this old world and the master mind that made it. There should be no conflict between science and religion. One verifies the other. To the scientist the Bible is much like his text-book and the world of nature is his laboratory.
14. He can help him to live more intelligently as a citizen among men, and enjoy better health for himself, for a knowledge of chemistry is an aid to good health.

Surely we need offer no apology for the teaching of chemistry if the boy or girl can be thus quickened and the teaching of high school chemistry certainly is well worth while.

MINUTES OF THE WASHINGTON MEETING OF THE DIVISION OF CHEMICAL EDUCATION OF THE AMERICAN CHEMICAL SOCIETY

The Division of Chemical Education opened its activities on Monday morning, April 21st at nine o'clock when the Committee on Chemical Education held a meeting for the purpose of putting the standard minimum high school Chemistry Outline in harmony with the 30,000 criticisms received since the Milwaukee meeting. Dr. Gordon, Secretary of the Section, had tabulated for the convenience of the committee a voluminous report embodying criticisms of the Outline received from every state in the Union.

This Chemistry Outline as originally printed in preliminary form in *Industrial and Engineering Chemistry* and in *School Science and Mathematics* was considerably reduced in amount and the final outline was adopted by the Division. A complete tentative correlation plan for high school and college chemistry was worked out with a preliminary outline of topics which might serve as a starting point in drawing up a college freshman chemistry outline. It was moved and passed by the Division to print the entire correlation plan including the high school and college outlines in the May issue of THIS JOURNAL.

At the Council meeting Monday afternoon the Committee on Chemical Education through its Chairman, Dr. Neil E. Gordon, made a report of its activities on three projects which it has had under execution since the Milwaukee meeting: (1) correlation of high school and college chemistry, (2) organization of state associations of chemistry teachers, and (3) organization of the JOURNAL OF CHEMICAL EDUCATION. The report was favorably received and it was recommended that a committee be appointed to continue the work.

The formal meeting of the Section opened Thursday morning with Dr. Edgar F. Smith as Chairman, and was continued Friday morning and afternoon. In accordance with authorization from the Council the Section now became a Division. Dr. Neil E. Gordon of the Department of Chemistry at the University of Maryland, College Park, Maryland was elected Chairman of the Division, and Mr. Wilhelm Segerblom, Head of the Department of Chemistry at the Phillips Exeter Academy, Exeter, New Hampshire was elected Secretary.

On Thursday morning a dozen papers were read and aroused considerable discussion. As it is hoped that most of these will be printed in the JOURNAL OF CHEMICAL EDUCATION they need not be commented on individually here. Discussions accompanying the papers will also be printed. Subscription to the JOURNAL OF CHEMICAL EDUCATION will supply chemistry teachers with valuable information on the present trend of chemical education as brought out in these papers and discussions.

The papers of Friday were devoted largely to high school chemistry. In the afternoon the Committee on Chemical Education made its report and the business meeting was held. It was moved that the drawing up of a constitution for the Division be left in the hands of the officers. It was decided that in the reading of papers before the Division the regular A.C.S. procedure be followed. The organization of state associations of chemistry teachers where no such state associations already exist was approved and encouraged. A letter from Dr. H. E. Howe, Chairman of the A.C.S. Prize Essay Contest regarding the reading of papers submitted by the candidates was read. It was moved (1) that the Division accept Dr. Howe's invitation to read the essays, (2) that the essays be divided into six divisions to correspond with the topics suggested in the rules of the contest and (3) that the chair appoint for each topic a committee of not more than three to read the essays. It was moved that for future meetings the Secretary

obtain the time required for reading each paper and print this time with each title in the program.

It was voted that the following committees be appointed by the chairman: (1) A Committee of three to draft problems on research in Chemical Education; (2) A Committee of two to make recommendations to the A.C.S. Committee on nomenclature; (3) A Committee of three to take up the matter of the study of chemistry by women's clubs.

Voted that the members of the Division of Chemical Education express their thanks to Mrs. Sherman and approve her idea of activity of women's clubs along chemical lines. Discussion brought out the sentiment that possibly the poor standing of chemistry pupils was due as much to poor teaching as to poor students. The business meeting closed with a vote of thanks (moved by Dr. Lyman C. Newell) to Dr. Neil E. Gordon for his tireless services in getting the Division of Chemical Education started. To this expression of appreciation Dr. Gordon responded feelingly, emphasizing the hearty coöperation which he had met everywhere in connection with this work.

WILHELM SEGERBLOM
Secretary of Division of Chemical Education

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Local Activities and Opportunities

Future Chemists: The Chemia, an organization of C. L. A. students at Boston University vitally interested in chemistry in all its phases, held an open meeting Monday, April 7 at 5 P.M. Dr. Lyman C. Newell, head of the department of chemistry, gave an illustrated lecture on "Famous New England Chemists," one of several talks he has given recently before the New England department of the American Chemical Society and the New England Association of Chemistry Teachers. Following the lecture there was a discussion period and social hour. Refreshments were served.

Students who have advanced beyond the first year in chemistry, or intend to continue chemistry are eligible for membership.

A Chemical Debate: Since chemical spelling matches are now attracting attention and doing much to improve one phase of the use of English among chemists, it may not be without interest to know of another effort to vary routine recitations. One of the classes in Advanced Inorganic Chemistry at the University of Illinois recently held a debate on the subject: "Resolved, that the credit for the discovery of element No. 72 should be given to Coster and Hevesy."

Some weeks before the debate was scheduled the class elected two leaders who chose sides. A bibliography was prepared and given to all members of the class. Each side selected two of its members as speakers. J. B. Baker and E. F. Fiock representing the affirmative and J. W. Neckers and Thomas De Vries the negative. Other members of each team were assigned the tasks of collecting material and making translations. The debate was conducted according to the usual rules for such exercises, and the speeches showed that the literature had been thoroughly scanned, and the evidence carefully weighed and interpreted. No decision was rendered, but all the members of the class are awaiting the decision of the International Committee with the keenest interest.

University of Illinois: David Weason, Technical Director of the Southern Cotton Oil Company, addressed the University of Illinois section on the evening of May 2nd, on "Cotton Considered as a Food Crop." This lecture was illustrated by stereopticon views and moving pictures.

Arthur W. Ingersoll, Ph.D., now at the University of Tennessee, will be an instructor in the Organic Division of the University of Illinois during the Summer Session.

B. L. Souther, formerly instructor at the University of Illinois is now a Research Fellow at Mellon Institute, Pittsburgh.

Dr. Harry N. Holmes will give two courses in the Summer Session of the Colorado Agricultural College, Fort Collins, Colo., June 16 to July 23,—Methods of Teaching Chemistry and Recent Advances in Chemistry.

New England Association of Chemistry Teachers: Following is a resolution passed by this association:

WHEREAS: The Maryland Chemistry Teachers' Association has just been organized; and,

WHEREAS: The New England Association of Chemistry Teachers has until now been the only organization exclusively devoted to the interests of secondary school chemistry teachers;

Resolved: That the New England Association of Chemistry Teachers at its twenty-fifth anniversary meeting at Malden, Massachusetts, express its welcome to the Maryland Chemistry Teachers' Association and looks forward to mutually helpful relations therewith.

The Summer Session of Middlebury College consists of five special schools among which is a School of Chemistry established in 1920. The curriculum of this school includes all the courses offered by the regular Department of Chemistry and, in addition, courses designed to accommodate certain special classes of students, such as, teachers of Chemistry in preparatory schools, premedical students, etc. The advanced work in the School makes it possible to obtain the degree of Master of Science by attendance upon the Summer Session only. This is a convenient arrangement for teachers. One of the striking features of the School is the arrangement of week-end trips into the famous Battell forest of over 30,000 acres, sometimes called "Middlebury's back campus," through which the Long Trail of the Green Mountain Club is maintained. Professor P. Conant Voter, Middlebury, Vt., Chairman of the Chemistry Department, is Dean of the School.

NATIONAL ACADEMY

(Science Service)

The National Academy of Sciences closed its annual meeting in its new building at Washington, April 30th, by unanimously awarding medals for distinguished service to six scientists of this country and Europe.

Dr. Bashford Dean of Columbia University was voted the Daniel Giraud Elliott Medal for 1921 for his Bibliography of Fishes.

Dr. William Morton Wheeler of Harvard University was selected to receive the Elliott Medal for 1922 for his work on the ants of the Congo.

Dr. Ferdinand Canu of Versailles, France, was chosen for the Elliott Medal for 1923 for his work in classifying certain plant like fossil sea animals which is of great value to practical geologists.

Dr. Otto Sven Pettersson of the International Institute for Study of the Sea, Borno bei Holma, Sweden, was awarded the Agassiz Medal for his studies on the chemistry and physics of the sea.

Dr. A. S. Eddington, of the Cambridge Observatory, England, the Henry Draper Medal, for his contributions to knowledge of what the stars are like inside.

And Dr. C. V. Ludvig Charlier of the University of Lund, Sweden, was picked for the Watson Medal for his outstanding contributions to astronomical science concerning motion and distribution of the stars.

Fifteen prominent American Scientists were elected to membership in the National Academy of Sciences at the closing session of this annual meeting. Election to the Academy is considered one of the highest of honors in the scientific world. The men elected and their achievements are as follows:

Dr. Charles Elmer Allen is professor of Botany at the University of Wisconsin and is editor of the American Journal of Botany.

Dr. Stanley Rossiter Benedict is professor of chemistry at the Cornell University Medical School. He has made an especial study of the chemistry of uric acid.

Dr. William Crowell Bray, associate professor of chemistry at the University of California, was associate director of the fixed nitrogen research laboratory during 1919 and has studied the problems connected with the internal energy of the atom.

Dr. Arthur Byron Coble, eminent mathematician of the University of Illinois.

Dr. Karl Taylor Compton, physicist of Princeton University, who has done remarkable work on radio detectors and in making X-ray photographs of the structure of crystals.

Dr. Raymond Dodge, psychologist of Wesleyan University who has made experimental study of nervous fatigue and done pioneer research on the question of human variability.

Dr. George Sumner Huntington, Columbia University morphologist who has traced the development of the internal anatomy of back-boned animals.

Dr. Arthur Becket Lamb, chemist, of Harvard University and former member of the U. S. Fixed Nitrogen Commission and Chemical Warfare Service, who has made a special study of methods of removing deadly carbon monoxide from the air.

Dr. Andrew C. Lawson is a geologist at the University of California. He has specialized in economic geology, earthquakes, and the geology of California.

Dr. Frederick George Novy is director of the hygienic laboratory at the University of Michigan. He has specialized in bacteriology and hygiene and has studied the bacteria of plague and other deadly diseases.

Dr. Frederick Belding Power of the Bureau of Chemistry, U. S. Department of Agriculture, discovered the active principle of chaulmoogra oil which is used in the treatment of leprosy. He is a world authority on plant chemistry.

Dr. Charles Edward St. John of Mt. Wilson Observatory, who reported to the Academy at this meeting that his observations of the shift of the spectrum lines of sunlight confirmed Einstein's theory.

Dr. Harlow Shapley, director of the Harvard College Observatory, who recently discovered a new universe billions of miles beyond our own planetary system.

Dr. Lorande Loss Woodruff is professor of zoölogy at Yale University and has made special study of the lowest forms of animal life as well as of the history of biology.

Dr. Hans Zinsser of the Harvard Medical School is a student of epidemics and their causes and has done much experimental work on the cause of cancer.

BOOK REVIEWS

Fundamentals of Chemistry. By C. W. GRAY, C. W. SANDIFUR, AND H. J. HANNAH, Los Angeles High Schools, California. Houghton Mifflin Company, Boston, New York, Chicago, San Francisco. The Riverside Press, Cambridge, Massachusetts, 1924. 445 pp. 12.5 × 18.5 cm. 197 illustrations. 8 portraits.

This unique book breaks away from some of the traditional subject matter of high school chemistry and especially from the order of its presentation. In doing so, these courageous authors move in the direction of the signs of the times.

To those who look upon high school chemistry as a "college preparatory subject" this book might seem to deintellectualize chemistry by omitting: methods for the exact determination of the constituents of pure water, the exposure of secondary school students to mere mathematical handling of gas laws, the development of the atomic and molecular theories, and the methods for the determination of atomic and molecular weights. Such omissions are wise because the exposure of the average high school student to them takes little abiding effect, and that little becomes extinct by the time it is applied by those who go to college in the study of college chemistry, or is rememebered as instruments of torture by the large majority who do not go to college. Instead of giving those topics the formality of chapters this book uses subject matter which converts chemistry into coin for the currency of human needs. Enough of the usual theory and essential principles is introduced in a clear pedagogical manner, where there are fine practical contacts, to make this book, so rich in practicalities, rest on a firm chemical basis.

Oxygen comes next, at the conclusion of which there is given just enough of the Law of Definite Composition, molecular and atomic structure of matter, valency and formula writing of oxides to be well understood. Then follow water, hydrogen, bases from metallic oxides and water, and commercial methods and useful applications of bases. Equation writing and radicals precede the well edited chapter on stoichiometry. This is followed by a chapter on the Gas Laws which is introduced by explosions and a diagram of a longitudinal section of an automobile. From these contacts practical problems apply the gas laws with abosrbing interest and profit. Three chapters treat of the non-metals, non-metallic oxides, ionization and the theory of electrons. The shifting of electrons is cited as accounting for the charges on the ions. Since radio and radio tubes are universally serviceable they form a fine contact of interest and serve to illuminate the ionic conceptions.

Twenty-four chapters of timely topics having a commercial significance indespensible to daily life are presented with a fine balance between the practical and the theoretical. This book should be on the desk of every high school teacher of chemistry, for, if it is not desired for adoption as a text-book, it will give many valuable points and methods as a companion to the chemical text-book in use.

Technical High School
Washington, D. C.
LOUIS W. MATTERN

Charts of the Chemical Reactions of the Common Elements. By JOHN A. TIMM, Ph.D. Instructor in Chemistry, Yale University. John Wiley and Sons, New York, 1924. ix + 81 pp. 24.5 × 18 cm.

This book will be heartily welcomed by those who teach elementary inorganic chemistry. Thirty-one common elements are treated fully first by a chart which covers either one or two pages according to the number of compounds and processes involved, and second by a page of complete equations covering all reactions indicated in the chart.

To give an idea of the book let me follow through the first chart, that of aluminium. The first line gives the name, the symbol, its group in the periodic classification and its valences. Occurrence on the next line includes only the more important naturally occurring compounds with mineral names often given. The more important compounds of each element are then arranged from left to right in the order of increasing valence of the element; that is, the hydride, if it exists, at the extreme left with its negative valence, then the free element with zero valence and then the oxides with the positive valence. Vertical lines drawn downward from these formulas give starting points for horizontal lines leading to the formulas of important salts. Arrow points on the horizontal lines indicate in which direction reactions run. A word or two of explanation is occasionally inserted on these lines. On each arrow is found a small number referring to the proper equation in the list of equations.

The charts are arranged in alphabetical order. Considering the vast amount of information indicated, the charts are remarkably clear. Directions for use are brief and little difficulty should be experienced on the part of either teacher or pupil in learning to use the charts. To the reviewer's mind these charts reveal clearly and at a glance all the essential descriptive data that a first year student need know. No typographical errors caught the reviewer's eye but the formulas and equations were not verified with a view to catching such errors. The teaching profession will be especially indebted to Prof. Timm, and those of us who enjoy charts will thumb the book a good deal.

The Phillips Exeter Academy
Exeter, N. H.
WILHELM SEGERBLOM